



2005 Hidden Ocean Expedition

Three Cold Realms

FOCUS

Pelagic, benthic and sea ice realms

GRADE LEVEL

5-6 (Biology)

FOCUS QUESTION

What organisms are typical of the pelagic, benthic and sea ice realms in the Arctic Ocean?

LEARNING OBJECTIVES

Students will be able to compare and contrast the pelagic, benthic and sea ice realms of the Arctic Ocean.

Students will be able to name at least three organisms that are typical of each of these three realms.

Students will be able to explain how the pelagic, benthic and sea ice realms interact with each other.

MATERIALS

☐ None

AUDIO/VISUAL MATERIALS

☐ None

TEACHING TIME

One or two 45-minute class periods, plus time for student research and preparation

SEATING ARRANGEMENT

Three groups of students

MAXIMUM NUMBER OF STUDENTS

30

KEY WORDS

Pelagic realm
Benthic realm
Sea ice realm
Sympagic
Brine channel
Arctic Ocean
Canada Basin

BACKGROUND INFORMATION

The Arctic Ocean is the most inaccessible and least-studied of all the Earth's major oceans. Although it is the smallest of the world's four oceans, the Arctic Ocean has a total area of about 14 million square kilometers (5.4 million square miles); roughly 1.5 times the size of the United States. The deepest parts of the Arctic Ocean (5,441 m; 17,850 ft), known as the Canada Basin, are particularly isolated and unexplored because of year-round ice cover. To a large extent, the Canada Basin is also geographically isolated by the largest continental shelf of any ocean (average depth about 50 meters) bordering Eurasia and North American. The Chukchi Sea provides a connection with the Pacific Ocean via the Bering Strait, but this connection is very narrow and shallow, so most water exchange is with the Atlantic Ocean via the Greenland Sea. This isolation makes it likely that unique species have evolved in the Canada Basin.

The 2002 NOAA Ocean Exploration expedition

to the Arctic Ocean focused specifically on the biology and oceanography of the Canada Basin. These explorations included three distinct biological communities:

- The Sea-Ice Realm includes plants and animals that live on, in, and just under the ice that floats on the Ocean's surface;
- The Pelagic Realm includes organisms that live in the water column between the ocean surface and the bottom;
- The Benthic Realm is composed of organisms that live on the bottom, including sponges, bivalves, crustaceans, polychaete worms, sea anemones, bryozoans, tunicates, and ascidians.

These realms are linked in many ways, and food webs in each realm interact with those of the other realms.

Sea ice provides a complex habitat for many species that are called sympagic, which means "ice-associated." The ice is riddled with a network of tunnels called brine channels that range in size from microscopic (a few thousandths of a millimeter) to more than an inch in diameter. Some areas of Arctic sea ice persist throughout the year, and endemic species (species that are not found anywhere else) have developed in the multi-year sea ice of the deep ocean basins. Diatoms and algae inhabit these channels and obtain energy from sunlight to produce biological material through photosynthesis (a process called "primary production"). Bacteria, viruses, and fungi also inhabit the channels, and together with diatoms and algae provide an energy source (food) for flatworms, crustaceans, and other animals. In the spring, melting ice releases organisms and nutrients that interact with the ocean water below the ice. Large masses of algae form at the ice-seawater interface and may form filaments several meters long. On average, more than 50% of the primary production in the Arctic Ocean comes from single-celled algae that live near the ice-seawater junction. This interface is critical to the polar marine ecosystem, providing

an energy source (food) for many organisms, as well as protection from predators. Arctic cod use the interface area as nursery grounds, and in turn provide an important food source for many marine mammals and birds, as well as migration routes for polar bears. In the spring, the solid ice cover breaks into floes of pack ice that can transport organisms, nutrients, and pollutants over thousands of kilometers. Partial melting of sea ice during the summer months produces ponds on the ice surface called polynyas that contain their own communities of organisms. Because only 50% of this ice melts in the summer, ice flows can exist for many years and can reach a thickness of more than 2 m (6 ft).

When sea ice melts, more sunlight enters the sea, and algae grow rapidly since the sun shines for 24 hours a day during the summer. These algae provide energy for a variety of pelagic organisms, including floating crustaceans and jellyfishes called zooplankton, which are the energy source for larger pelagic animals including fishes, squids, seals, and whales. When pelagic organisms die, they settle to the ocean bottom, and become the energy source for inhabitants of the benthic realm. These animals, in turn, provide energy for bottom-feeding fishes, whales, and seals.

Exploration of the Arctic Ocean, especially the Canada Basin, has become increasingly urgent because the Arctic environment is changing at a dramatic rate. A 2004 report from the Arctic Council states that temperature in the Arctic is increasing at nearly twice the rate of increase as the rest of the world. One visible result is rapid loss of glaciers and sea ice. Less visible are the impacts on living organisms that depend upon glaciers and sea ice for their habitat. Loss of these habitats can also have direct effects on human communities. The Greenland Ice Sheet, for example, holds enough water to raise global sea levels by as much as 7 meters. Sea level increases at this magnitude would be sufficient to flood many coastal cities, including most of the city of London.

A key objective of the 2005 Hidden Ocean expedition is to make significant contributions to the Arctic Ocean Census of Marine Life, which is aimed at documenting present Arctic Ocean biodiversity throughout the Arctic region. This information is essential to monitoring the effects of Arctic climate change, since it provides the “baseline” that allows change to be detected and quantified. The Arctic Ocean census is part of the Census of Marine Life which is a network of researchers in more than 70 nations who are “engaged in a ten-year initiative to assess and explain the diversity, distribution, and abundance of marine life in the oceans—past, present, and future.”

This lesson is intended to introduce students to the “Three Realms” of marine life in the Canada Basin, and to the diversity of organisms that inhabit these realms.

LEARNING PROCEDURE

1. To become more familiar with the Hidden Ocean expedition, you may want to visit the expedition’s Web page (<http://oceanexplorer.noaa.gov/explorations/05arctic/welcome.html>) for an overview of the expedition and background essays. You should also review the following essays from the 2002 Hidden Ocean expedition:
 - Deep Sea Benthos (<http://oceanexplorer.noaa.gov/explorations/02arctic/background/benthos/benthos.html>)
 - Spineless Wonders: The Pelagic Fauna (<http://oceanexplorer.noaa.gov/explorations/02arctic/background/fauna/fauna.html>)
 - Arctic Sea Ice: Channels of Life (http://oceanexplorer.noaa.gov/explorations/02arctic/background/sea_ice/sea_ice.html)

If students will not have access to the internet for this lesson, you may want to make copies of these lessons, as well as the Web pages for “Water Column,” “Sea Ice,” and “Sea Bottom” in the Arctic Ocean Biodiversity Web site (<http://www.sfos.uaf.edu/research/arcddiv/index.html>). You may also want to prepare a background sheet for

the collage that students will create using the schematic diagram of the three realms on the Arctic Ocean Biodiversity introduction page as a guide.

2. Briefly review the geography of the Arctic Ocean, highlighting the location of the Canada Basin and the activities of the Hidden Ocean expedition. Introduce the “three realms” of marine life in the Canada Basin. You may also want to briefly discuss Arctic climate change and why it is so important to gather information on species that presently inhabit the three realms as soon as possible.
3. Divide students into three groups. Tell students that their assignment is to
 - Research one of the three realms;
 - Find out what kinds of organisms inhabit their assigned realm;
 - Obtain a picture of each organism;
 - Work with other groups to assemble a collage that illustrates the inhabitants of the three realms; and
 - Prepare a brief report describing their assigned realm and how it interacts with the other two realms.

You may want to bring a bit of taxonomy into the lesson by having students include a label on their images giving the classification of the organism (phylum and class) as well as its common name.

4. Direct students to the Arctic Ocean Biodiversity Web site and to the Hidden Ocean expedition pages on the Ocean Explorer Web site. Call students’ attention to the “Photo and Video Log” section of the Ocean Explorer Web site which contains images that they may want to use for their collage.
5. Have each group present an oral summary of their written report, then lead a discussion of students’ collage of the three realms. These

reports and discussions should include the following points:

- Many inhabitants of the sea ice realm are endemic to this ecosystem.
- Sea ice inhabitants include protozoa, turbellaria, nematodes, rotifers, and amphipods; in the spring larvae and juveniles of benthic animals are also found in the ice.
- In addition to providing a feeding ground for larvae and juveniles of benthic animals, the sea ice realm is linked to the pelagic realm by Arctic cod which feed on the amphipods that inhabit the underside of ice floes; the cod, in turn, are an important food source for seals, birds, whales, and predatory fishes.
- Fauna of the pelagic realm (water column) are dominated by small crustaceans and “jelly animals”; the latter are not well-known because they are usually destroyed in sampling nets.
- Pelagic realm inhabitants include protists, cnidaria, ctenophores, polychaetes, pteropods, cephalopods, heteropods, cladocerans, ostracods, copepods, mysids, amphipods, euphausiids, decapods, chaetognaths, tunicates, and fishes.
- Inhabitants of the benthic realm are constrained by food supplies, because they depend primarily on food particles that settle from higher in the water column or that are transported from the continental slopes. This means that many other organisms have had access to the food particles before they reach the bottom, so benthic organisms are left with what has been missed or rejected by inhabitants of the pelagic realm.
- Benthic realm inhabitants include polychaetes, crustaceans, bivalves, fishes, anemones, and tunicates. Shells of scaphopods and gastropods have also been recovered from deep areas, but these may have been deposited from the continental shelves. Be sure students understand that the Sea Bottom page on the Arctic Ocean Biodiversity Web site includes images of organisms found in

shallow waters as well as those of the deep benthos.

THE BRIDGE CONNECTION

www.vims.edu/bridge/ – Type “arctic” in the search box in the upper right corner to find links to information and activities concerning the Arctic region.

THE “ME” CONNECTION

Have students write a brief essay explaining why they think it is important (or not important) to explore areas such as the Canada Basin. If some students believe these activities are unimportant, point out that many of the most promising drugs for serious human diseases (such as cancer) are being found in rather unimpressive organisms that live in the deep sea.

CONNECTIONS TO OTHER SUBJECTS

English/Language Arts, Geography

EVALUATION

Student reports prepared in Learning Procedure Step 3, the group collage and discussions in Step 5 provide opportunities for assessment.

EXTENSIONS

1. Have students visit <http://oceanexplorer.noaa.gov> to keep up to date with the latest 2005 Hidden Ocean Expedition discoveries.
2. Visit http://oceanexplorer.noaa.gov/explorations/02arctic/background/education/media/arctic_lessonplans.html for more lesson plans and activities related to the 2002 Hidden Ocean expedition.

RESOURCES

<http://oceanexplorer.noaa.gov> – Follow the 2005 Hidden Ocean Expedition daily as documentaries and discoveries are posted each day for your classroom use.

<http://www.coml.org/descrip/aobio.htm> – The Arctic Ocean biodiversity section of the Census of Marine Life Web site

<http://www.arctic.noaa.gov/> – NOAA's Arctic theme page with numerous links to other relevant sites.

<http://maps.grida.no/arctic/> – Thematic maps of the Arctic region showing populations, ecoregions, etc.

<http://www.thearctic.is/> – A Web resource on human-environment relationships in the Arctic.

<http://www.dfo-mpo.gc.ca/regionhs/CENTRAL/arcexplor> — Web site produced by Fisheries and Oceans Canada on the Arctic.

NATIONAL SCIENCE EDUCATION STANDARDS

Content Standard A: Science As Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard C: Life Science

- Populations and ecosystems
- Diversity and adaptations of organisms

Content Standard F: Science in Personal and Social Perspectives

- Populations, resources, and environments
- Natural hazards

FOR MORE INFORMATION

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